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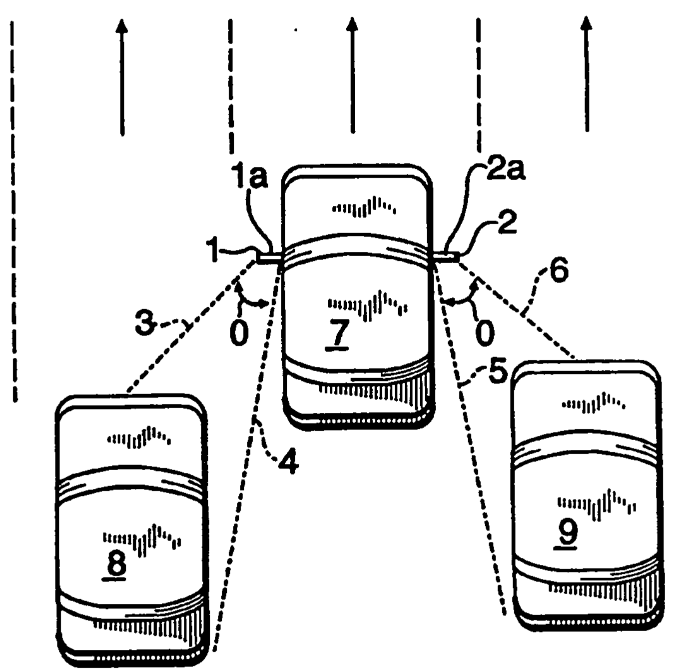
(57) Abstract

A device for detecting the presence of an object in the blind spot of a vehicle comprises a passive infrared sensor mountable on the vehicle so as to have its field of view directed toward the blind spot. The infrared sensor generates a signal in response to a heat-emitting object moving about its field of view. A bandpass filter passes signals having a frequency within a predetermined band characteristic of moving vehicles. An indicator indicates the presence of an object upon detection of a signal in the predetermined band.



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BLIND SPOT DETECTOR

This invention relates to a blind spot detector for use in moving vehicles, particularly, but not exclusively, automobiles. It can also be applied to other applications, for example, detecting the presence of children near a school bus.

It has been a long recognized problem that the driver of an automobile has a blind spot on either side of the vehicle to the rear of the driver's position in which overtaking vehicles are not visible either in the rear view mirror or the side mirrors. This can lead to potentially dangerous situations when the driver changes lanes, particularly in dense traffic. Quite often two cars may proceed in parallel with the trailing car remaining in the blind spot of the leading car for some considerable period of time. If the leading driver changes lanes without properly making a visual check of his blind spots, a collision can result.

In the prior art, various attempts have been made to provide detection devices for detecting the presence of objects in the blind spot. An example of one such device is described in US Patent No. 5,122,796. This patent discloses a vehicle detector which employs an electro-optical emitter for sending a light beam to a trailing vehicle and a receiver for picking up the light reflected from the vehicle. This device is typical of the prior art in that it requires an active transmitting element to direct a light beam to the vehicle to be detected. US Patent No. 4,260,980 discloses a similar arrangement employing ultrasonic waves. US Patent No. 3,697,985 discloses a system employing Doppler radar systems.

The systems described in the above patent have in common the fact that they are active systems; that is they require the use of a transmitter to send some sort of signal which is reflected off the trailing vehicle and

picked up by a detector on the leading vehicle. Such active devices are relatively expensive to make and are very sensitive to contamination by dirt and the like thrown up from the road. Such active devices have a significant power consumption and need to be hard wired into the vehicle electrical system.

US Patent No. 3,681,750 discloses a passive system which relies on the detector picking up ultrasonic emissions from the trailing vehicle. Such a device requires a frusto-conical horn to pick up the ultrasonic signals from the appropriate direction, but even with such a horn the system has poor positional discrimination. Furthermore, the horn has a significant size and thus impairs the aerodynamic and aesthetic qualities of the vehicle.

US patent no. 5,249,128 discloses the use of a passive infrared detector for range sensing. There is no teaching of blind spot detection or how to discriminate vehicle signals from false signals generated, for example, by the road surface.

An object of the invention is to provide a small, low cost blind spot detector that can be conveniently attached to a vehicle without the need to hard wire it into the vehicle electrical system.

According to the present invention there is provided a device for detecting the presence of an object in the blind spot of a moving vehicle, comprising a passive infrared motion sensor mountable on the vehicle so as to have its field of view directed toward the blind spot, said infrared sensor generating a signal in response to a heat-emitting object moving about its field of view; a bandpass filter for passing signals having a frequency within a predetermined band characteristic of moving vehicles; and an indicator for indicating the presence of

an object upon detection of a signal in said predetermined band.

The detector according to the invention is responsive to the heat generated by the engine of the trailing vehicle. A simple low cost passive infrared motion sensor, developed for the home security market, is preferred. A suitable sensor is dual element lithium tantalate crystal with a low noise FET transistor mounted on a substrate and enclosed in a metal housing with a silicon window having part number HEIMANN LHI 958.

Such a sensor has a Fresnel lens with well defined lobes. The lithium tantalate crystals discharge when infrared radiation falls on them. When an object moves across the field of view of the detector, it moves across the response lobes so as to generate an output signal. If the two objects are stationary relative to each other, no output signal is produced.

The vehicle carrying the sensor is of course moving along the road. If the road surface were at a uniform temperature, it would be produce no output signal. In practice, due to differential heating the road surface does produce an output signal at the detector that can be as large as that caused by the trailing vehicle. It has been found, however, that differential heating causes a distinctly different signature from a moving vehicle. Generally road signals primarily lie in the frequency range below 0.5Hz. These signals are mostly excluded by the bandpass filter.

When two vehicles are traveling in parallel along the highway, the random motion of the trailing vehicle across the field of view of the detector will result in the detection of the trailing vehicle even if the two vehicles are moving along the road at the same speed.

Such a detector can be made at extremely low cost due in part to the fact that motion sensors are mass

produced for the security market. The sensors are rugged and consume low power since the control circuitry can be made using CMOS devices. Using lithium batteries, the battery life is expected to exceed six months continuous use under average operating conditions. It is envisaged that the device will be attached, preferably adhesively, to the side view mirrors of a vehicle and left permanently on. In the idle state, the current drain will be very small indeed.

When a vehicle is detected, a light-emitting diode will be illuminated, and this will be visible through the side window from the driver's position.

Unlike most infrared sensing devices working in the required temperature range, the inventive device does not require a chopper, cryogenic cooling unit, or germanium lenses. Only a very simple signaling conditioning circuit is required.

The Fresnel lenses are preferably made of polyethylene.

An important preferred aspect of the invention is the ability to adapt to changing meteorological conditions. For example, in periods of heavy rain, car signatures are reduced due to the cooling effect of rain. Fortunately, the road signature is also reduced due to the fact that the thermal mass of the rain evens out the temperature variations in the road surface. In the preferred embodiment, the invention exploits this effect to adaptively adjust the threshold at which a vehicle is considered present depending on the number of noise events detected below the present threshold in a predetermined period of time. For example, if a large number of noise events are detected, the threshold is raised. If only a few are detected the threshold is lowered. This makes the detector more sensitive, but only

when there is relatively little road noise, for example during periods of heavy rain.

The invention also provides a method of detecting the presence of an object device for detecting the presence of an object in the blind spot of a moving vehicle, characterized in that it comprises directing a passive infrared sensor toward the blind spot, said infrared sensor generating a signal in response to a heat-emitting object moving about its field of view; passing signals through a bandpass filter for having a frequency within a predetermined band characteristic of moving vehicles; and indicating the presence of an object upon detection of a signal in said predetermined band.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a plan view showing three vehicles moving along adjacent lanes in a highway;

Figure 2 is a rear view of the vehicles shown in Figure 1;

Figure 3 is a diagrammatic view showing the angular response of the infrared detector;

Figure 4a is a circuit diagram of the signal conditioning circuit;

Figures 4b to 4f show the signal at various stages in the signal conditioning circuit; and

Figure 5 shows the voltage regulator for the conditioning circuit;

Figure 6 shows the system field of view in the direction of travel in more detail;

Figure 7 shows the amplifier frequency response of a second embodiment;

Figure 8 is a system block diagram of the second embodiment;

Figure 9 is a top level flow chart describing the operation of the second embodiment;

Figure 10 is a noise measurement flow chart for the second embodiment;

Figure 11 is a flow chart showing the car detection operation of the second embodiment;

Figure 12 is a flow chart describing the threshold setting operation;

Figure 13 shows the lens configuration in elevational view; and

Figure 14 shows the lens configuration in plan view; and

Figure 15 is a detailed circuit diagram of the second embodiment.

Referring now to Figure 1, vehicles 7, 8 and 9 are shown moving along adjacent lanes of a highway, with vehicles 8 and 9 in the blind spot on either side of vehicle 7.

Vehicle 7 has side view mirrors 1, 2 with respective passive infrared detectors 1a, 2a mounted thereon. Each infrared detector has a horizontal field of view θ. The field of view of detector 1a has respective outer and inner edges 3, 4, whereas the detector 2a has a field of view θ with respect to inner and outer edges 5, 6. These edges are chosen to outline the vehicle blind spot.

Figure 2 shows the same layout from the rear, and thus shows the field of view ϕ of the detectors 1a, 2a in the vertical plane. AS will be apparent from Figures 1 and 2, the detectors 1a, 2a have a generally downward directed conical field of view covering the vehicle blind

spot. Vehicles outside this conical field of view are not normally detected.

The detectors 1a, 2a are normally mounted on the side view mirrors with an adhesive. The detectors include red light-emitting diodes that are visible from the driver's position and that illuminate when a moving heat-emitting source is detected in the field of view θ, ϕ of the detectors 1a, 2a. This alerts the driver to the presence of a vehicle in the blind spot, although before switching lanes the driver should still make a quick visual check by glancing over his shoulder.

The passive infrared motion detectors employed in the device have lenses that give an angular response as shown in Figure 3, that is they have a series of radial lobes 10 in the circumferential direction. This means that the detector has its greatest response along radii a, c, with a minimum along radius b between the radii a and c. The crystals are arranged so that a stationary object produces a zero output signal.

As an object moves across the field of view from a to c, the radiation received by the crystals within the detector passes through a minimum at b maximum at c. This creates an output signal from the crystals, which in the invention is used to detect the presence of an object. The relative movement of the object and detector is caused in part the random motion of the trailing vehicle across the field of view of the detector.

This output signal is conditioned by the conditioning circuit shown in Figure 4a. Referring now to Figure 4, the signal conditioning circuit comprises a detector 20, a filter amplifier 30, an amplifier 40, a comparator 50 and a monostable circuit 60. The detector includes the passive infrared sensor 21 which is supplied with steady voltage V_2 provided by the voltage regulator shown in Figure 5. The voltage V_2 is supplied through

series resistors R_1, R_2. These resistors in conjunction with the capacitor C_2 provide a ripple-free voltage supply to the sensor 21.

The output voltage of the detector 20, which is in the microvolt range, is shown in Figure 4a. When a target is detected, the spike 22 occurs.

The filter/amplifier 30 comprises two operational amplifiers 31, 32, which form a band pass filter that matches the output frequency response of the infrared sensor and discriminates vehicle response from road noise. The circuit also provides a significant amount of gain, providing an output signal in the millivolt range as shown in Figure 4b.

The output of circuit 30 is applied to amplifier circuit 40, which comprises operational amplifier 41. This provides further amplification and also DC filtering through capacitor C8. The output voltage is offset with a voltage provided by resistor network R11 and R12. The output of amplifier circuit 40, which is shown in Figure 4c, is a circuit in the millivolt range.

The output amplifier 40 is applied to comparator 50, comprising operational amplifiers 51, 52. Comparator 50 is a decision-making circuit that defines upper and lower bounds of the input signal (Figure 4d). These are set with variable resistor R15, which therefore sets the sensitivity of the circuit. When the comparator 50 registers the target, due to the signal falling outside the upper and lower bounds, as shown in Figure 4d, the comparator produces a falling edge voltage signal of small duration at its output. This filter signal is in the volt range and is applied to monostable multivibrator 60, which is a falling edge triggered circuit used to prolong the duration of the output signal of the comparator. The output signal, shown in figure 4e, is an output pulse whose duration is set by resistor R20 and

capacitor C11. The output of monostable 60 is a voltage signal in the volt range, which is used to drive LED 62 that acts as a visual indicator to the driver of the presence of a target.

The conditioning circuit shown in Figure 4 is implemented in CMOS and therefore has very low power consumption. This is also helped by the fact that it is purely a passive, non-radiating device.

The detector normally operates in the 6 to 14 micron long wave infrared radiation and is generally responsive to the heat emitted by the engines of moving vehicles. It has been found that the device responds well to vehicle engines with minimal false indications.

While the device has been designed particularly with automobiles in mind, it can be applied to other applications, for example aircraft applications, where there is a need to detect the presence of heat-emitting targets.

The detectors are attached to the side mirrors by a durable automotive adhesive. Since they are self-contained and battery operated, no wiring or electrical connection to the vehicle electrical system is required. This means they can be distributed as low-cost accessories for easy non-invasive application by the vehicle owner. All he has to do is stick the device in the appropriate position where it is visible from the driver's position through the vehicle window.

By using a lithium battery, continuous operation in excess of six months can be achieved. The device is not designed to be switched off. When no target is detected, the current consumption is nominal.

If desired, an additional LED having a different color, such as a amber LED, can be provided to give early warning of a low battery condition.

The optics of the passive infrared detector will now be discussed in more detail with reference to Figures 6, 13 and 14. This infrared detector could be used in either the first embodiment discussed above or in the second embodiment to be described below.

The infrared detector only responds to changes in observed temperature across its field of view. Thus, it is only possible for the system to detect objects which cross the field of view. Objects coming straight towards the sensor produce little or now response. For this reason the FoV is angled out from the vehicle direction by about 20° ±5° so that vehicles entering the blind spot actual are forced to cross the FoV.

Secondly the optimum focal length has been found to be about 25 mm. Shorter focal lengths give a larger FoV (field of view), but produce a lower effective car frequency signature. This makes separation of car and road signatures difficult or impossible. Longer focal lengths have several disadvantages:

a) The narrower spot beam requires better alignment.

b) The beam may not cover the hot spot on the car.

c) More lens elements are required to give the required horizontal coverage.

d) A larger physical size of the unit is required to house the larger optics.

The optics is arranged to give the FoV shown in Figure 6. The alignment must be fairly precise to get this FoV. Three angles are involved which can be termed yaw, pitch, and roll. Yaw determines the Horizontal FoV and is least critical of the three. It is established by the user simply by aligning a reference line towards the rear of the car. Tolerance is ± 5°. The roll angle determines the extent to which the FoV extends to the

side of the car. Ideally the FoV of view would be limited to the adjacent lane (3.5 m). In fact, it is chosen to extend slightly beyond this so that sufficient signature is picked up from cars in the blind spot. The result is that occasionally there will be triggering from cars one lane over. Roll angle should be 15° ± 2°. Pitch is the most critical angle and determines basically how far the FoV extends behind the car. If it is too high objects very far away (buildings , setting sun etc.) will give false triggers. If it is too low the vehicle will not be detected until it is well into the blind spot. Pitch angle is set to 1.5° ± 1°.

Pitch and roll angles are set by the user placing a circular level on a surface of the device which when level is set to give the correct roll and pitch angles.

The device 1a, 2a uses eight lens elements (i...viii) to give horizontal coverage of about 60°, as shown in Figure 13.

The second embodiment, as shown in Figure 8, has a passive infrared detector 70, a bandpass amplifier 71, a detector circuit 72, an LED flasher 73, and a noise event counter 74.

The amplifier 71 has a specific bandpass characteristic to provide near optimal discrimination between vehicle and road background signatures. It has been determined experimentally that with proper optical alignment, the electronic signatures of vehicles lie primarily in the region above 0.5 Hz. while the electronic signatures of the road background lie primarily below 0.5 Hz.

In bright sunshine because of differential heating of the road surface, the background signature can easily be as large as that of a vehicle so that it is vital that these signatures be filtered out. The device has in fact three filters with high pass cut offs at 0.08, 0.7 and

0.7 Hz, respectively. As well a second order low pass filter cut off at 4.2 Hz is used to limit high frequency noise. The filter response is shown in Figure 7.

The signature received from cars is strongly dependent on weather conditions. Particularly in medium to heavy rain, the signature from vehicles can be dramatically reduced. Fortunately, it is possible for the device to determine when this condition exists by monitoring background noise as the background signature is reduced as well during rain - i.e. the road tends to be of more uniform temperature due to the high thermal mass of the rain water.

The blind spot detector takes advantage of this effect by counting noise values over a given threshold in the noise event counter 74. After a predetermined period, a threshold is chosen that depends on the number of noise counts over the noise threshold. Higher counts give higher thresholds. The period is determined by counting the number of samples below the lowest possible car detection threshold. Thus, the statistics are not upset by the presence or absence of vehicles in the blind spot.

Specifically, with the amplifier gain set to 66 dB the noise threshold used is 30 mv. The possible car detection thresholds are 50 mv, 100 mv , 150 mv and 200 mv. The count is done to a maximum of 32 events below 50 mv. Each event is sampled for about 800 msec so that a new threshold is chosen about every 25 sec if no events over 50 mv occur. The threshold for the next 25 sec interval is set based on the number of events between 30 and 50 mv as follows:

less than 3 events	Th = 50 mv
between 3 and 7 events	Th = 100 mv
between 8 and 20 events	Th = 150 mv
more than 20 events	Th = 200 mv

A time out check is also implemented to prevent the system locking up due to constant noise or car signatures over 50 mv. After one minute of this condition, the threshold is set to 200 mv.

The detailed operation of the second embodiment, which is microprocessor based, is illustrated in Figures 9 to 12.

The detailed circuitry for the second embodiment is shown in Figure 15. The circuit is controlled by microprocessor 100, which is a Motorola 6805. A signal from passive infrared detector 101 is fed through operational amplifiers 102, 103, which also act as bandpass filters. The output of amplifier 103 is fed to operational amplifiers 104, 105, which acts as comparators. Switches 106 provide the threshold adjustment circuitry.

The invention also has other applications, such as school bus child detectors. An integrated Multiple unit could cover a long vehicle, such as tractor trailers.

With the current invention, pickup of shadows from overpasses can occur, in particular on sunny days. This is because of the cooler road temperature under the underpass. It is possible to compensate for this by having two detectors with one pointing straight down at the road to establish the presence of a shadow. This information can then be combined with the data from the car detection sensor to reduce the detection of shadows.

The current invention takes advantage of the relative motion of the two vehicles to produce the detection signal. Normally in most driving situations this is sufficient to give a very high probability of detection. However it is conceivable, especially under heavy rain when car signatures are reduced, that relative motion may not be enough to trigger the device. This problem can be overcome by mechanically vibrating the

mirror, lens or sensor to provide a scanning motion of the car signature across the detector.

Claims:

1. A device for detecting the presence of an object in the blind spot of a vehicle, characterized in that it comprises a passive infrared motion sensor mountable on the vehicle so as to have its field of view directed toward the blind spot, said infrared sensor generating a signal in response to a heat-emitting object moving about its field of view; a bandpass filter for passing signals having a frequency within a predetermined band characteristic of moving vehicles; and an indicator for indicating the presence of an object upon detection of a signal in said predetermined band.

2. A device as claimed in claim 1, characterized in that said infrared detector further comprises a multi-lobe lens defining said field of view, said multi-lobe lens enhancing variations in said signal as the heat-emitting object moves across said field of view.

3. A device as claimed in claim 2, characterized in that said multi-lobe lens defines a generally cone-shaped field of view directable downward to the side of the vehicle.

4. A device as claimed in claim 2, characterized in that the field of view of said multi-lobe lens is angled out from the vehicle direction by about 20° ±5° so that vehicles entering the blind spot are forced to cross the field of view.

5. A device as claimed in claim 3, characterized in that said lens is a Fresnel lens.

6. A device as claimed in claim 5, characterized in that said Fresnel lens is made of polyethylene.

7. A device as claimed in claim 1, characterized in that said sensor is a dual element Lithium Tantalate crystal.

8. A device as claimed in any one of claims 1 to 7, characterized in that it further comprises a threshold detector, said threshold indicator only indicating the presence of an object when said signal exceeds said threshold.

9. A device as claimed in claim 8, characterized in that it further comprises means for adaptively adjusting said threshold in response to changing road conditions.

10. A device as claimed in claim 9, characterized in that said means for adaptively adjusting said threshold comprises a noise event counter, which counts the number of noise events below the present threshold within a predetermined period and adjusts said threshold in accordance with the number of noise counts within said predetermined period.

11. A device as claimed in claim 1, which is a self-contained unit mountable on an exterior portion of said vehicle.

12. A device as claimed in claim 11, characterized in that said self-contained unit is adhesively mountable on said exterior portion.

13. A device as claimed in claim 11, characterized in that said self-contained unit is adhesively mountable onto a side mirror of the vehicle.

14. A device as claimed in claim 1, characterized in that said indicator comprises a light-emitting device.

15. A device as claimed in claim 14, characterized in that said light-emitting device is a light-emitting diode.

16. A method of detecting the presence of an object device for detecting the presence of an object in the blind spot of a moving vehicle, characterized in that it comprises directing a passive infrared motion sensor toward the blind spot, said infrared sensor generating a

signal in response to a heat-emitting object moving about its field of view; passing signals through a bandpass filter for having a frequency within a predetermined band characteristic of moving vehicles; and indicating the presence of an object upon detection of a signal in said predetermined band.

17. A method as claimed in claim 16, characterized in that the presence of an object is only indicated when said signal exceeds a predetermined threshold.

18. A method as claimed in claim 17, characterized in that said threshold is adaptively adjusted in response to changing road conditions.

19. A device as claimed in claim 18, characterized in that the number of noise events below the present threshold within a predetermined period are counted, and said threshold is adjusted in accordance with the number of noise counts within said predetermined period.

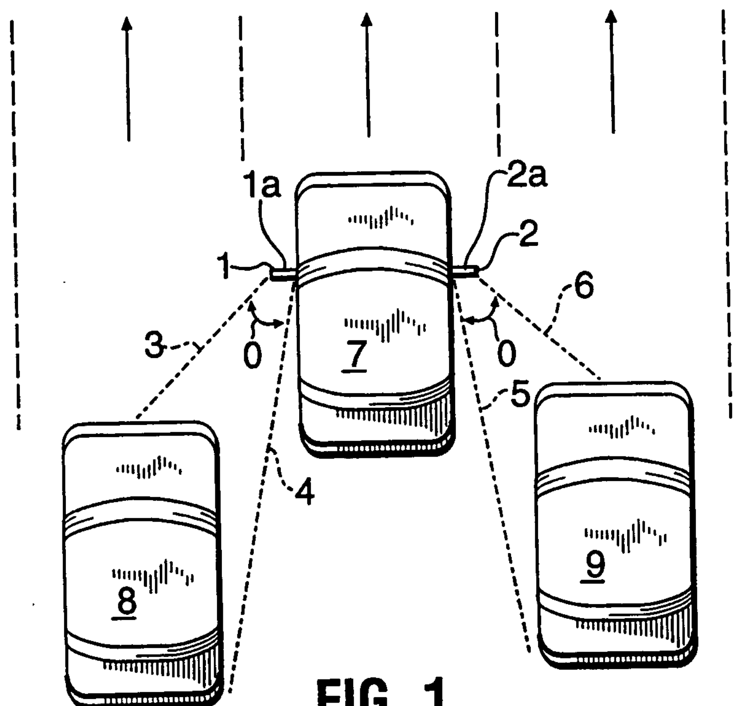

FIG. 1

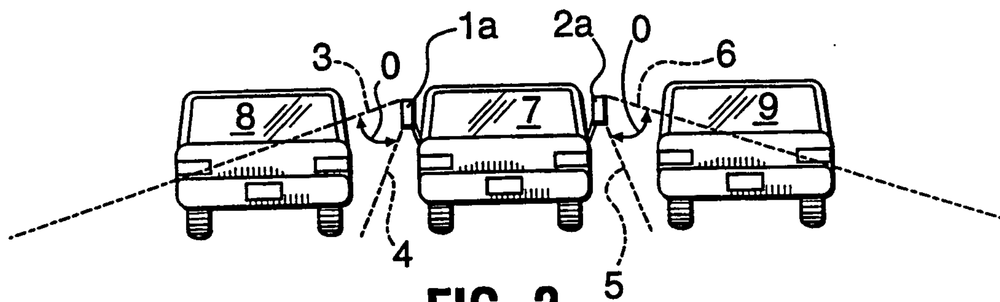

FIG. 2

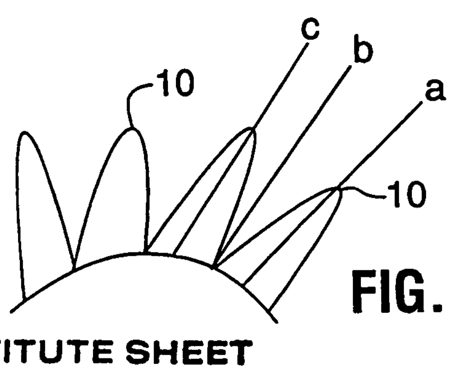

FIG. 3

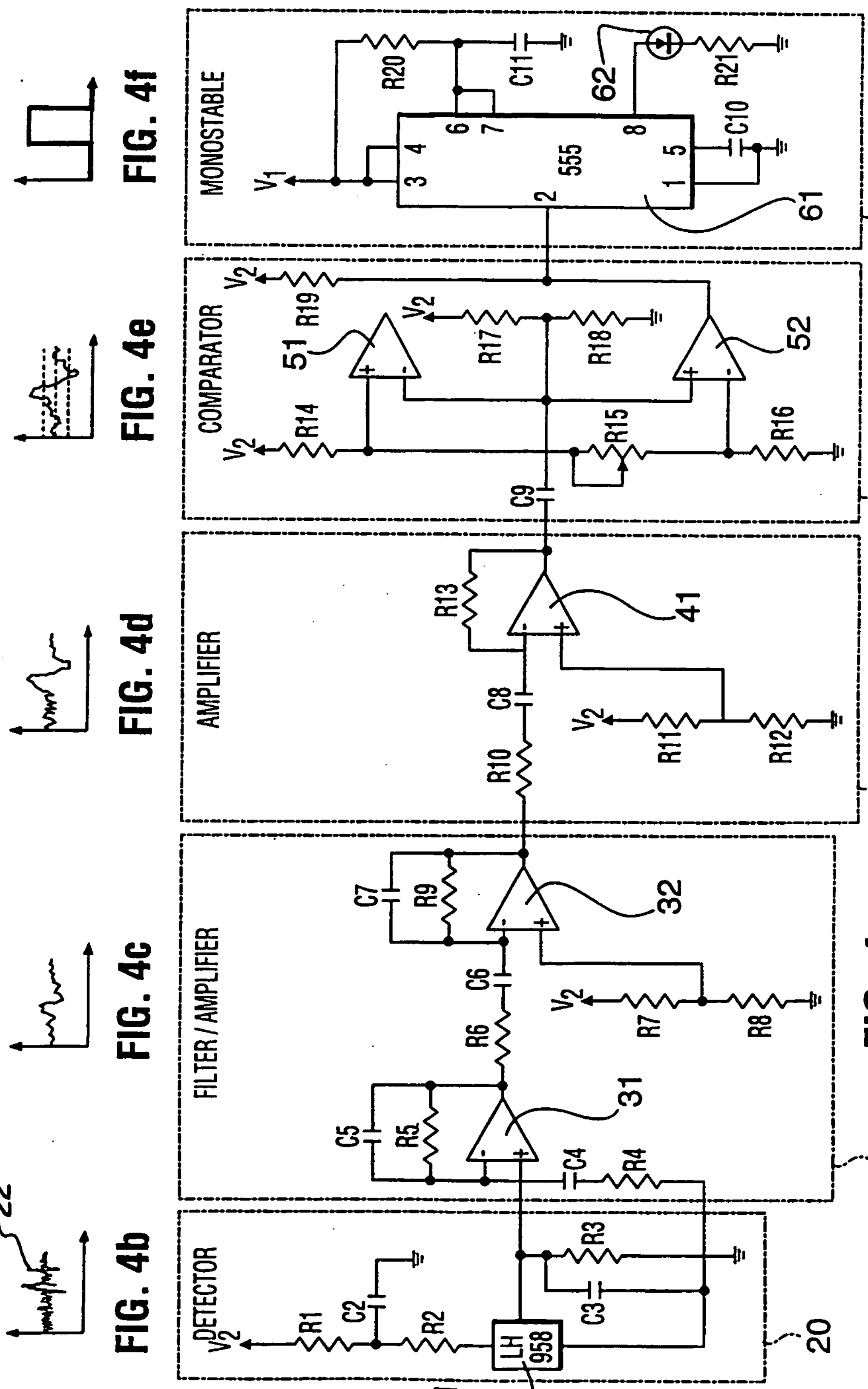

FIG. 4a

FIG. 4b

FIG. 4c

FIG. 4d

FIG. 4e

FIG. 4f

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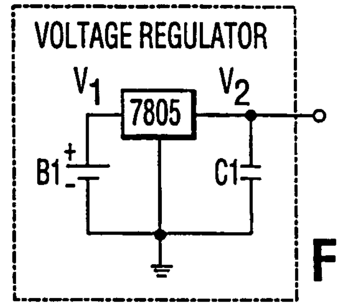


FIG. 5

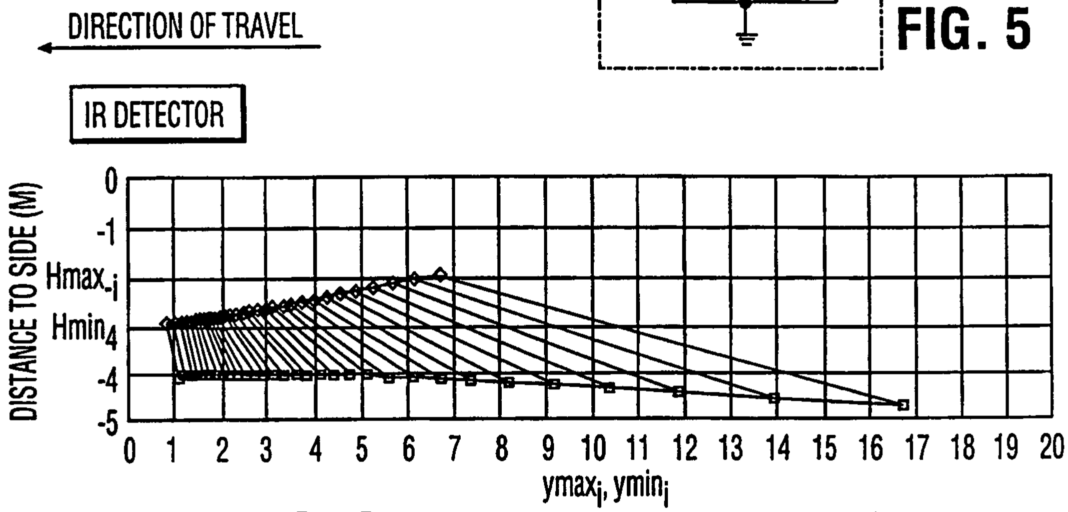


FIG. 6

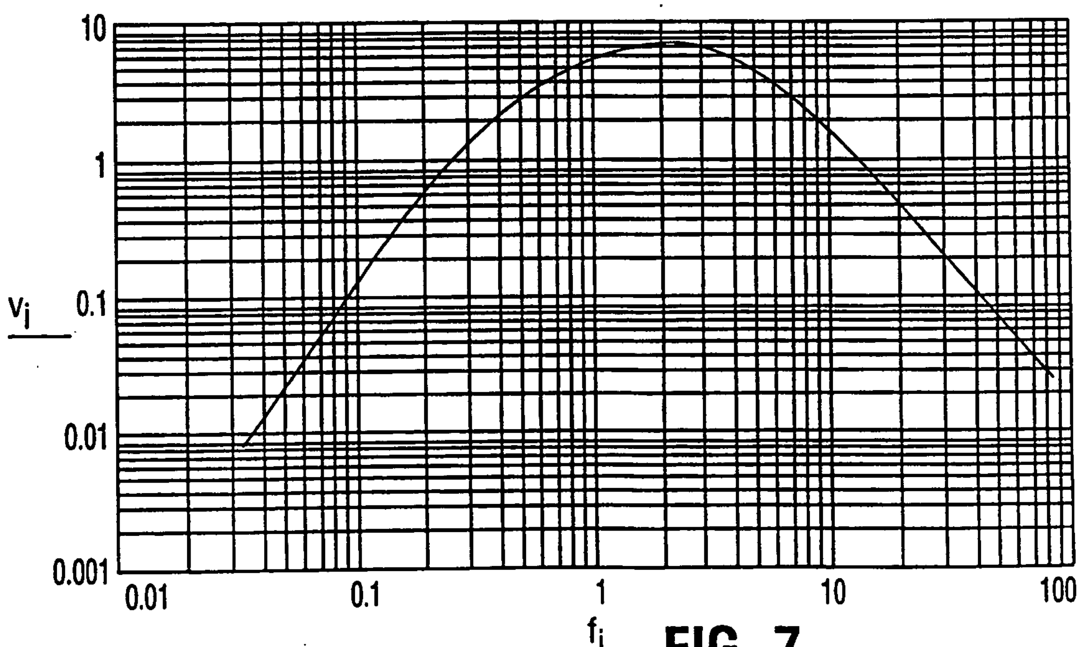


FIG. 7

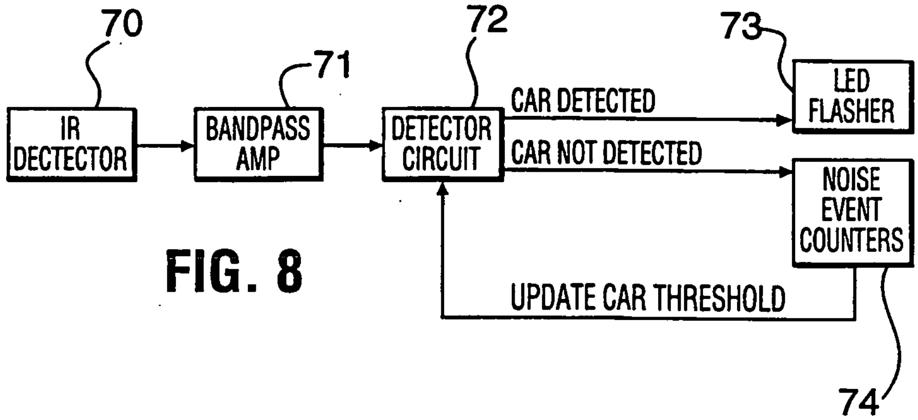
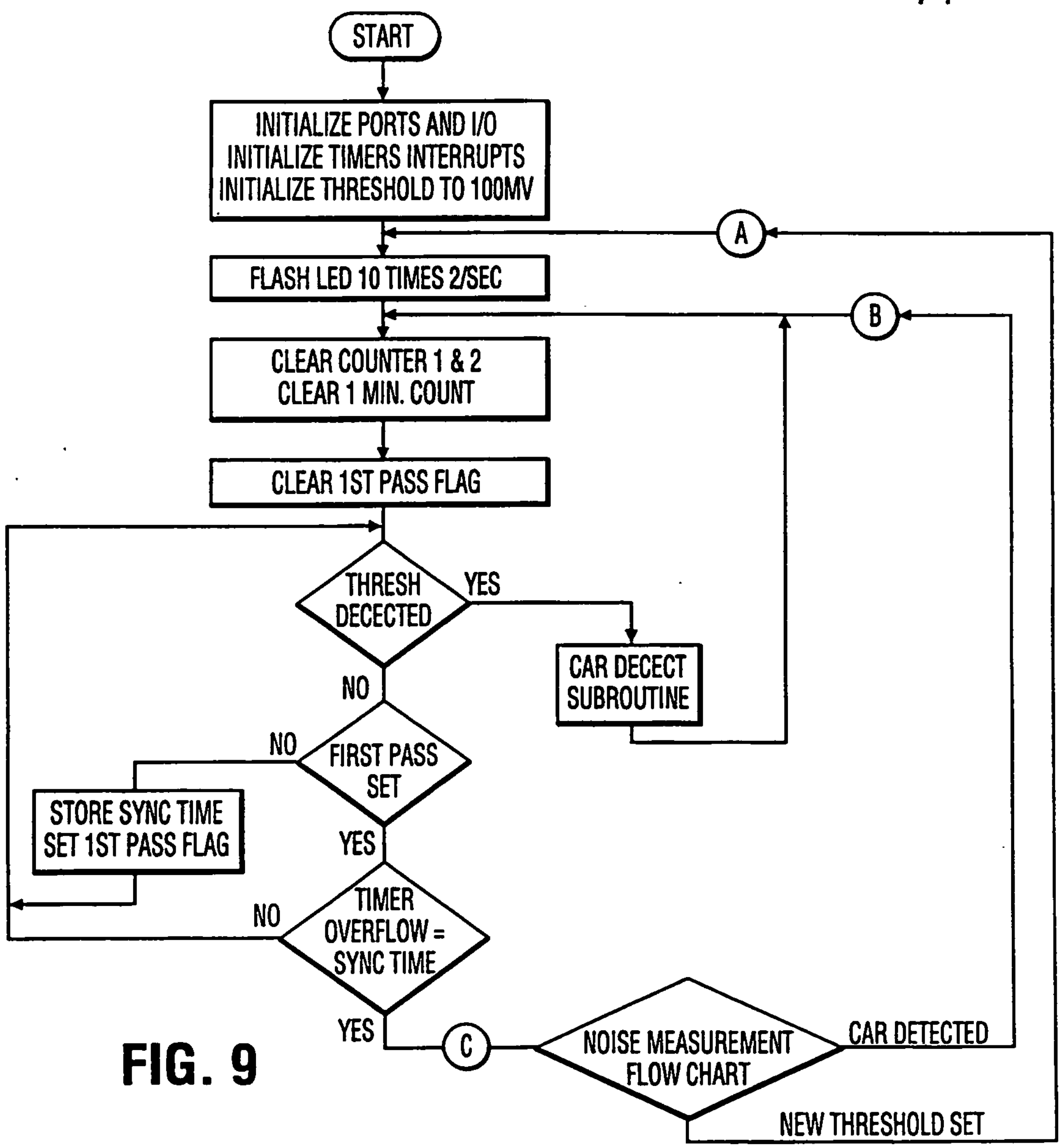

70
71
72
73
IR DECTECTOR
BANDPASS AMP
DETECTOR CIRCUIT
CAR DETECTED
CAR NOT DETECTED
LED FLASHER
NOISE EVENT COUNTERS
UPDATE CAR THRESHOLD
74

FIG. 8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INITIALIZE TIMERS INTERRUPTS
INITIALIZE THRESHOLD TO 100MV
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FLASH LED 10 TIMES 2/SEC
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CLEAR COUNTER 1 & 2
CLEAR 1 MIN. COUNT
CLEAR 1ST PASS FLAG
THRESH DECECTED
YES
CAR DECECT SUBROUTINE
NO
FIRST PASS SET
NO
STORE SYNC TIME
SET 1ST PASS FLAG
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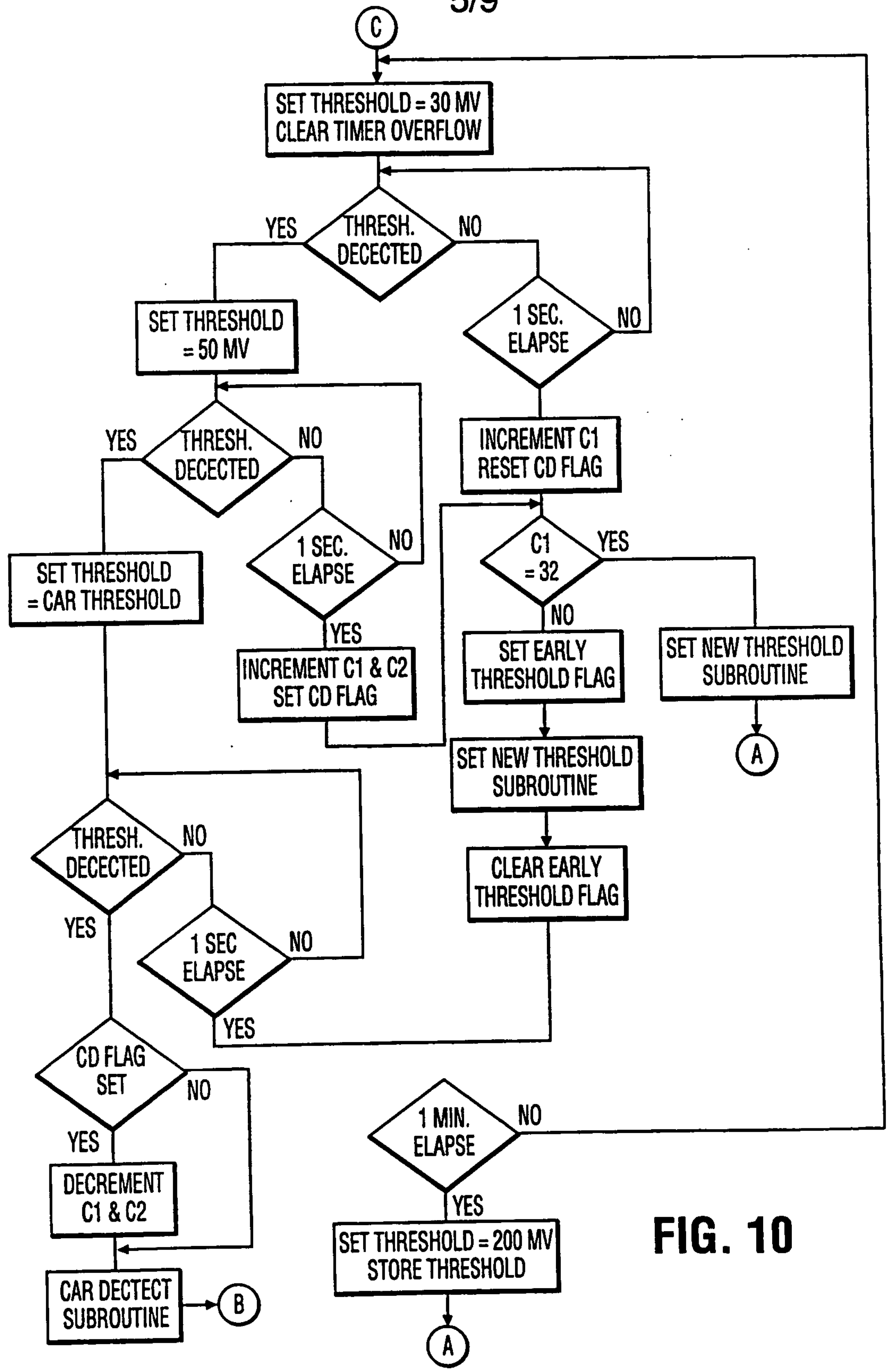
NEW THRESHOLD SET

FIG. 9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CLEAR TIMER OVERFLOW
THRESH. DECECTED
YES
NO
1 SEC. ELAPSE
NO
SET THRESHOLD = 50 MV
INCREMENT C1
RESET CD FLAG
THRESH. DECECTED
YES
NO
1 SEC. ELAPSE
NO
YES
C1 = 32
YES
NO
SET THRESHOLD = CAR THRESHOLD
INCREMENT C1 & C2
SET CD FLAG
SET EARLY THRESHOLD FLAG
SET NEW THRESHOLD SUBROUTINE
A
SET NEW THRESHOLD SUBROUTINE
THRESH. DECECTED
NO
YES
CLEAR EARLY THRESHOLD FLAG
1 SEC ELAPSE
NO
YES
CD FLAG SET
NO
YES
1 MIN. ELAPSE
NO
YES
DECREMENT C1 & C2
SET THRESHOLD = 200 MV
STORE THRESHOLD
CAR DECTECT SUBROUTINE
B
A

FIG. 10

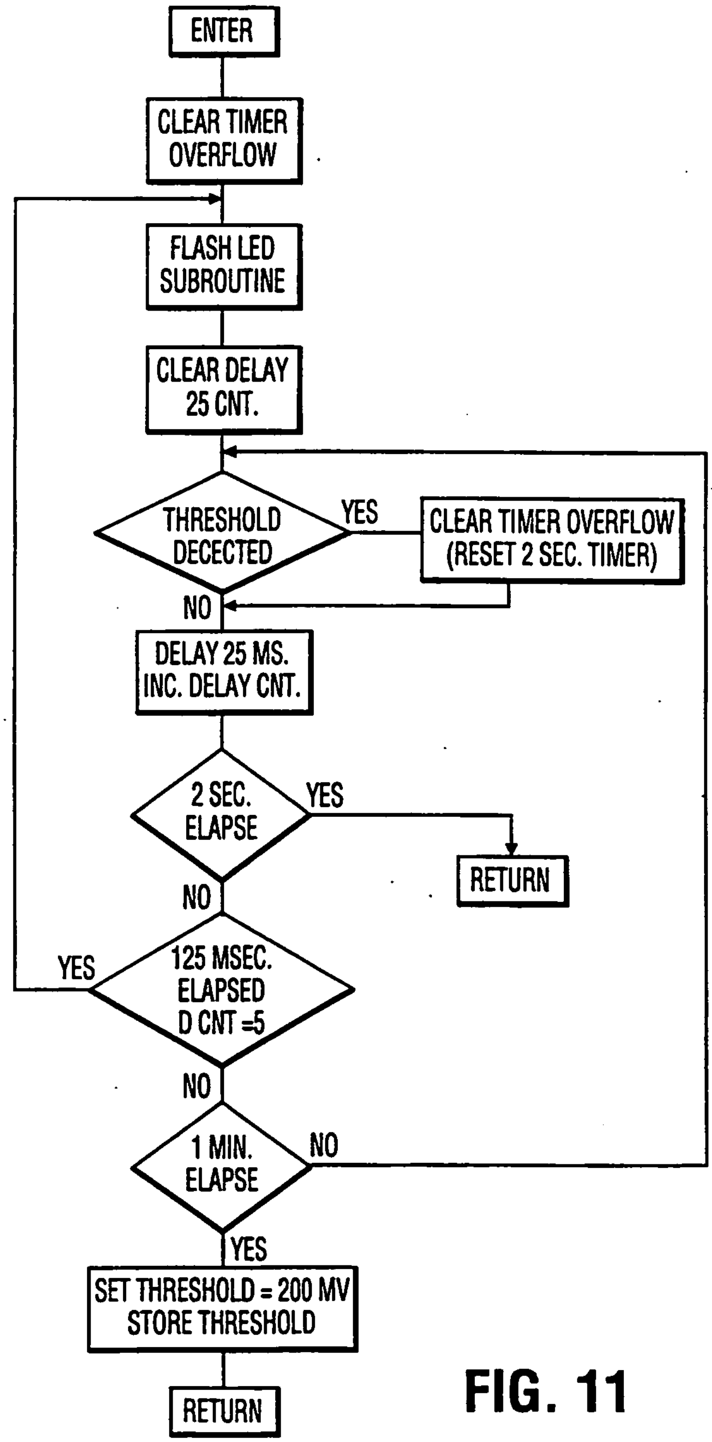

ENTER
CLEAR TIMER OVERFLOW
FLASH LED SUBROUTINE
CLEAR DELAY 25 CNT.
THRESHOLD DECECTED
YES
CLEAR TIMER OVERFLOW (RESET 2 SEC. TIMER)
NO
DELAY 25 MS. INC. DELAY CNT.
2 SEC. ELAPSE
YES
RETURN
NO
YES
125 MSEC. ELAPSED D CNT =5
NO
1 MIN. ELAPSE
NO
YES
SET THRESHOLD = 200 MV STORE THRESHOLD
RETURN

FIG. 11

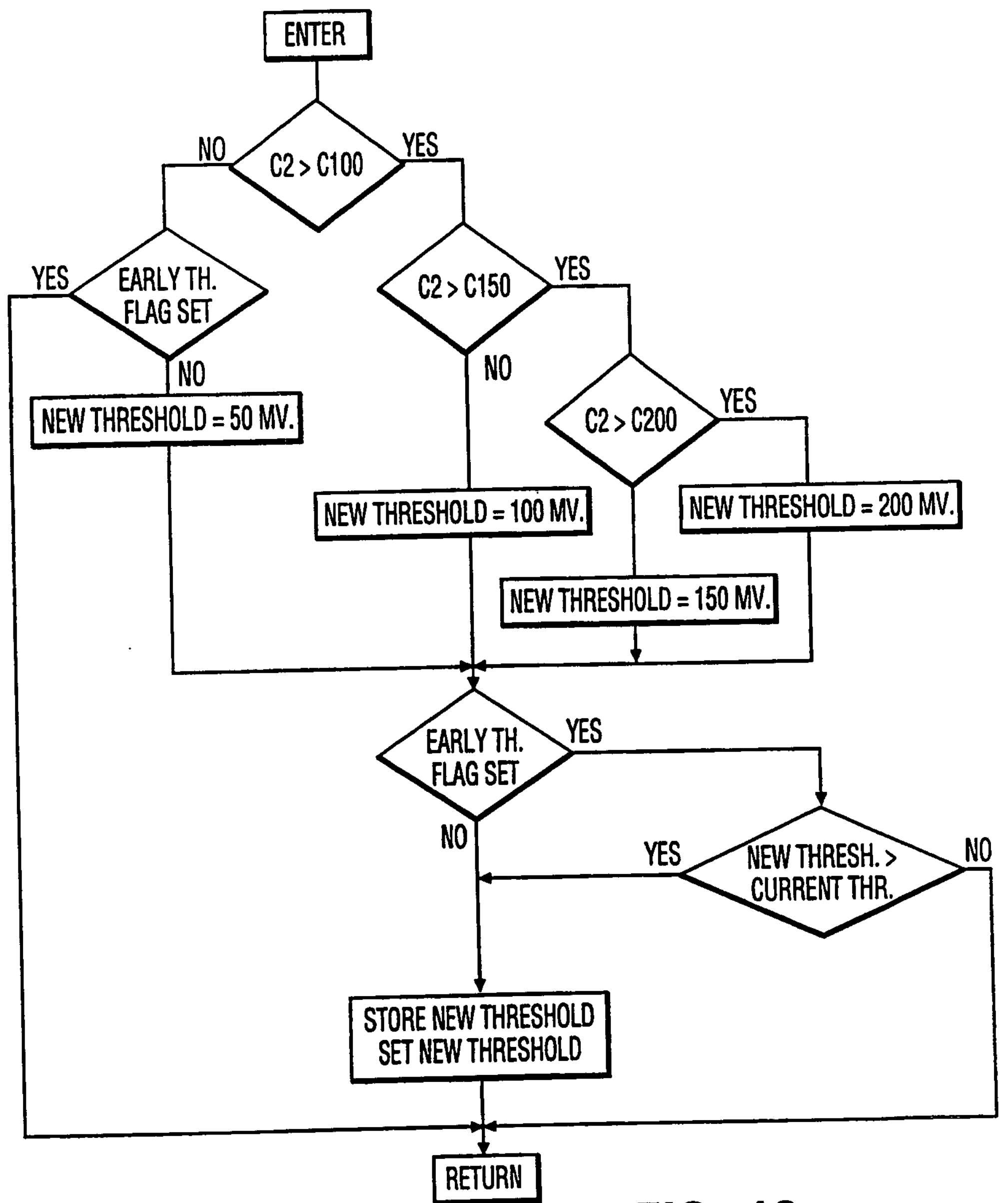
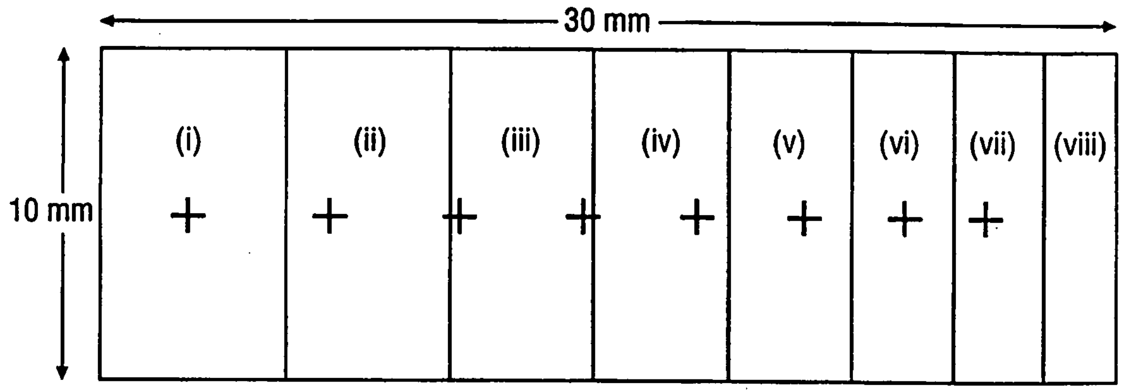

ENTER
C2 > C100
NO
YES
EARLY TH. FLAG SET
YES
NO
NEW THRESHOLD = 50 MV.
C2 > C150
YES
NO
NEW THRESHOLD = 100 MV.
C2 > C200
YES
NEW THRESHOLD = 200 MV.
NEW THRESHOLD = 150 MV.
EARLY TH. FLAG SET
YES
NO
NEW THRESH. > CURRENT THR.
YES
NO
STORE NEW THRESHOLD
SET NEW THRESHOLD
RETURN

FIG. 12



OPTICAL CENTERS

$$\begin{bmatrix} 2.645 \\ 6.635 \\ 10.525 \\ 14.227 \\ 17.675 \\ 20.824 \\ 23.656 \\ 26.171 \end{bmatrix} \text{mm}$$

LENS ELEMENT BOUNDARIES

$$\begin{bmatrix} 0 \\ 5.29 \\ 10.14 \\ 14.55 \\ 18.52 \\ 22.05 \\ 25.14 \\ 27.79 \\ 30 \end{bmatrix} \text{mm}$$

LENS SIZE = 10 MM X 30 MM
NUMBER OF ELEMENTS = 8
UV STABILIZED
THICKNESS = 0.6 MM
FOCAL LENGTH = 25 MM
RADIUS OF CURVATURE =24 MM

FIG. 13

FIELD OF VEIW CENTERS

$$\begin{bmatrix} 0 \\ 9.144 \\ 18.059 \\ 26.544 \\ 34.445 \\ 41.664 \\ 48.154 \\ 53.917 \end{bmatrix} \text{DEG.}$$

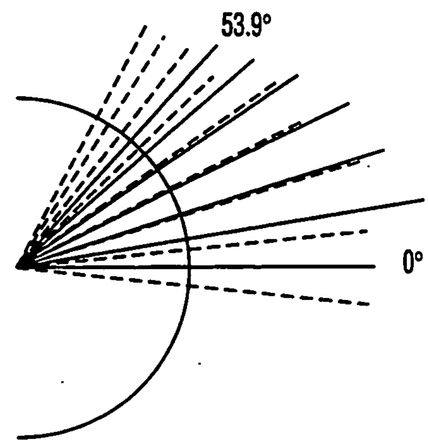
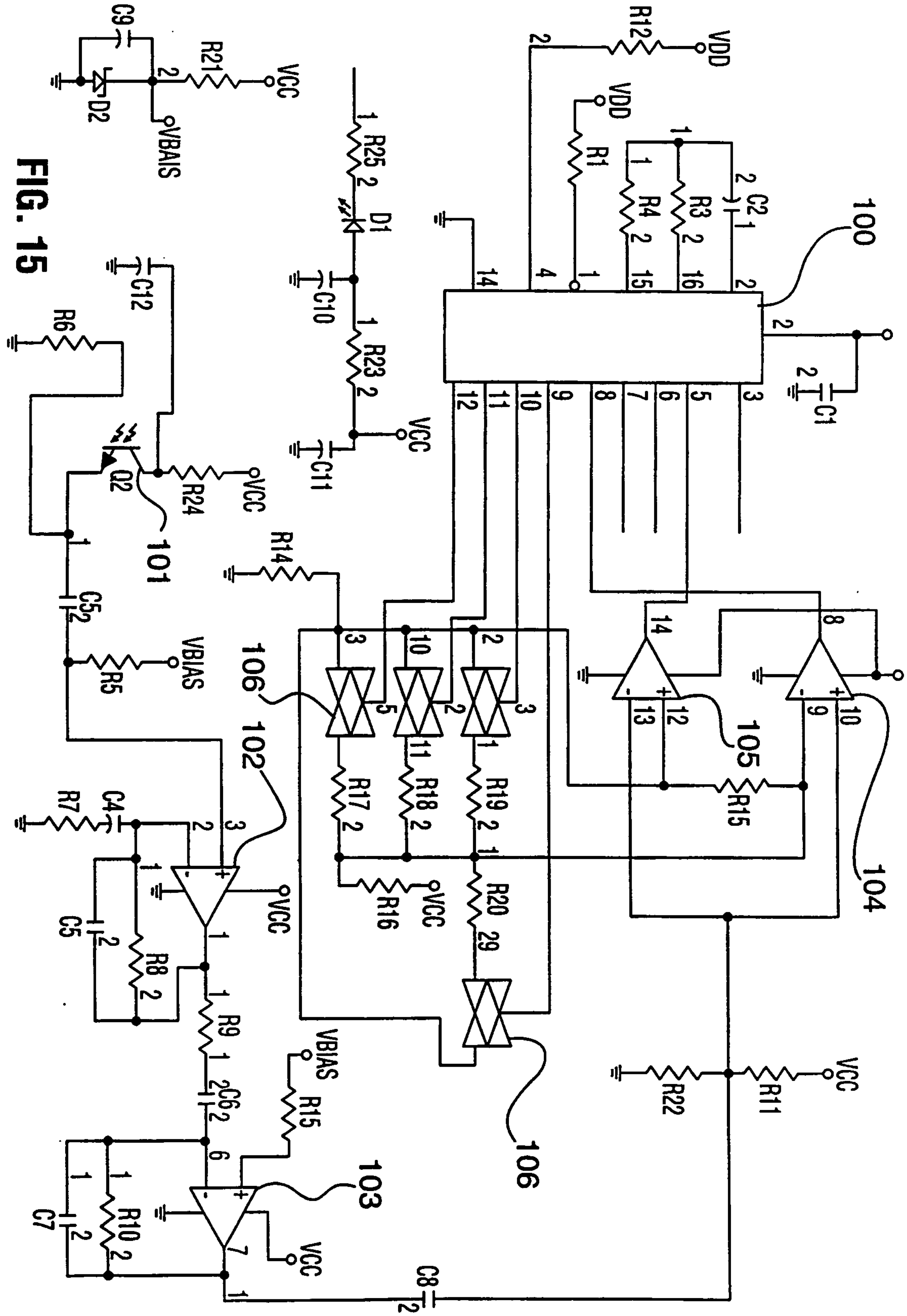


FIG. 14

SUBSTITUTE SHEET



100
101
102
103
104
105
106
106
VDD
VDD
VCC
VBIAS
VBAIS
R1
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
C1
C2
C4
C5
C6
C7
C8
C9
C10
C11
C12
D1
D2
Q2

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA 95/00134

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G08G 1/16
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B60R, G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Research Disclosure, June 1992, p 487, RD 33876, Anonymous: "Passive Infrared (IR) Blind Spot Detector for Vehicles", see whole document --	1,8,11-17
Y	US, A, 5012099 (S. PATUREL ET AL), 30 April 1991 (30.04.91), column 4, line 1 - line 16, figure 2 --	1,8,11-17
A	US, A, 4321594 (A.A. GALVIN ET AL), 23 March 1982 (23.03.82), column 1, line 37 - line 45 -- --------	5,6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "B" erlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 June 1995	12.07.95

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Göran Magnusson

SA 1''707

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/05/95

International application No.
PCT/CA 95/00134

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 5012099	30/04/91	DE-A- 3774423	12/12/91
		EP-A,B- 0276513	03/08/88
		FR-A,B- 2608777	24/06/88
		JP-A- 63172398	16/07/88
US-A- 4321594	23/03/82	NONE	